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(54) Name of the invention: Alumina-Zirconia-Titania Type Grinding Material

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(54) Alumina-Zirconia-Titania Type Grinding Material

Detailed Description of the Invention

1. Name of the Invention

Alumina-Zirconia-Titania Type Grinding Material

2. Scope of the Claims of the Invention

(1) Alumina-zirconia-titanium type grinding material that is a material obtained as zirconia and titania are added to alumina and melted, and then rapidly cooled, where then as another melting additive material yttrium oxide or rare earth type mineral ore material containing yttrium oxide are included.

(2) Alumina-zirconia-titanium type grinding material according to Claim 1 of the claims of the present invention where the added amount of yttrium oxide is in the range from 0.05 weight % to 7 weight %, relative to the total amount of the alumina, zirconia, and titania.

(3) Alumina-zirconia-titanium type grinding material according to Claim 1 of the claims of the present invention where the added amount of the yttrium oxide containing rare earth type ore material is in the range from 0.05 weight % to 7 weight %, relative to the total amount of the alumina, zirconia, and titania.

3. Detailed Explanation of the Invention

This invention is an invention about the improvement of the grinding (polishing) performance of alumina-zirconia-titania type grinding material.

Usually, the alumina-zirconia-type polishing particles are polishing particles that have been quickly expanded in their use as "snacking" of the steel type materials like specialty or stainless steel materials. Namely, compared to the alumina type polishing particles, they have excellent wear resistance and together with that breakage resistance etc., polishing properties, and the fact that under high pressure conditions, they demonstrate superior polishing strength, is the main factor. According to the invention reported in the description of the Japanese Patent Report Number Showa 48-35594, that has been invented previously by the authors of the present invention, an alumina-zirconia-titania material has been obtained that has a polishing performance that is even further increased and more superior than that.

Namely, it is a material where zirconia is added to alumina and together with that then titanium oxide is added in an amount that is in the range of 5 ~ 30 weight % relative to this zirconia amount, and then melted, and because of the fact that it is then quickly cooled, the phenomenon of the phase transformation back to the original zirconia is suppressed, and because of that the high temperature type tetragonal system crystalline phase remains present in an amount in the range of 25 ~ 30 % at normal temperatures, and due to that, it contributes to the increase in the wear resistance properties, breakage resistance properties, etc., polishing properties performance.

However, recently, there is a trend where the polishing methods have also constantly been changing, and the application of fine materials in the so-called heavy grinding field, and especially among those, the significant development of the technology of the change to the light grinding field within the heavy grinding, and also the use of the polishing materials for polishing relative to titanium alloys, has increased. A grinding material that is appropriate for this field is currently required, however, in this case, the required grinding performance is a performance that is higher than that of the above described alumina-zirconia-titania type grinding material, and especially, it is a material that cannot be a severe type of material, and the current status is that a grinding material with satisfactory grinding properties has not yet been obtained.

Namely, in order to be appropriate for the above-described application, it is necessary to suggest a grinding material where however it is stated it has a relatively high amount of zirconia, for example, a grinding material that is formed from a alumina-zirconia co-crystalline material of the type where the amount of zirconia is 40 %. However, in this case, even though it is an

alumina-zirconia-titania material obtained through the above-described titania addition, the ratio of the remaining existing high temperature type tetragonal crystal is extremely low, and the result from the addition is poor. Also, there have been the problems that the initial crystalline alpha-Al2O3, whose crystal size in the mixed crystalline material is a maximum of 20 microns, is separated at a level of 10 ~ 15 %, and because of that, the predetermined co-crystalline mixed material could not be obtained.

Then the goal of the present invention is to suggest an alumina-zirconia-titania type grinding material where in order that this material be good for application especially relative to heavy grinding, and especially to the light grinding, and then also, relative to titanium alloys, the remaining present amount of the tetragonal crystalline material is extraordinarily increased, and also, the coefficient of the separation of the original crystals of the alpha-Al2O3 is reduced, and because of that the grinding performance is significantly increased. And the characteristics of this material are the fact that it is an alumina-zirconia-titania type grinding material, where then as another additive material yttrium oxide or yttrium oxide containing rare earth ore material, is contained, and it is then called an alumina-zirconia-titania-yttria type grinding material.

Namely, as the additive materials, besides titania, yttrium oxide or yttrium oxide containing rare earth ore material are then added and mixed, and melted, and quickly cooled and by that, a grinding material is obtained that achieves well and satisfies the above described goal. And especially, it is a material where the added amount of the yttrium oxide or yttrium oxide containing rare earth ore material is within the range where it exceeds 0.5 weight % and is up to 7 weight % relative to the total amount of the alumina, zirconia, and titania, and where the zirconia tetragonal crystalline material is crystal separated at a remaining ratio that is in the range of 70 ~ 100 %. And not only that but also, within the same range, the ratio of the separation of the initial crystalline alpha-Al2O3 can be suppressed to a level below 5 weight %.

Moreover, even in the case when the added amount is higher than 7 weight % or below 0.05 weight %, the proportion of the remaining zirconia tetragonal crystal material shows a vale that is relatively high compared to the previous technology, and also, the ratio of the separated initial alpha-Al2O3 has a trend where it is significantly suppressed. However, in the case where the added amount exceeds 7 weight %, this leads to the separation of

a cubic crystalline phase, which is not preferable from the point of view of the grinding performance. And in the case when the added amount s less than 0.05 weight %, significant results are not obtained and because of that the range where the added amount is higher than 0.05 weight % and it is up to 7 weight %, is most appropriate, and especially, it is most appropriate that the added amount is within the range of 1 ~ 5 weight %.

Moreover, even, relative to a grinding material that contains an alumina-zirconia co-crystalline material with a relatively small amount of zirconia, for example, 25 %, the same way as in the case of the above-described grinding material that is formed from an alumina-zirconia co-crystallized material that contains a relatively large amount of zirconia, the ratio of the remaining tetragonal crystalline phase zirconia is extremely high, and because of that, the volume change, which occurs at the zirconia transition point is small, and also, the remaining present tetragonal crystalline type zirconia maintains sufficiently its inner part energy, and it has been concluded that there is a trend of improvement of the properties, like good breakage resistance properties, etc.

After that, the practical implementation examples according to the present invention will be explained.

Moreover, as the yttrium oxide or yttrium oxide containing rare earth ore material, that are used in the practical implementation examples according to the present invention, the materials with the analyses values shown according to Table 1, were used.

Table 1

第 1 表

	1 酸化イットリウム (wt%)	2 酸化イットリウムを含む稀土類鉱物 (wt%)
Y_2O_3	99.9	60
Fe_2O_3	0.0015	0.013
Na_2O	0.0015	–
K_2O	0.0015	–
SiO_2	0.001	0.05
La_2O_3	–	<10
CeO_2	–	<10
Nd_2O_3	–	<10
Yb_2O_3	–	6
Er_2O_3	–	6.5
Sm_2O_3	–	2

Headings in the table:

1. yttrium oxide (weight %), 2. rare earth ore material containing yttrium oxide (weight %).

Table 2:

第 2 表

試料番号	Y_2O_3 添加量 (wt%)	Al_2O_3	ZrO_2	TiO_2	Y_2O_3	Fe_2O_3	SiO_2	Na_2O
1	0	56.94	41.61	1.20	–	0.05	0.12	0.08
2	0.05	57.43	41.25	1.09	0.03	0.04	0.13	0.03
3	0.1	57.91	40.75	1.05	1.06	0.05	0.14	0.04
4	0.5	57.65	40.85	1.02	0.27	0.03	0.14	0.04
5	1	57.12	40.88	1.10	0.64	0.06	0.16	0.04
6	2.5	55.92	41.30	1.03	1.52	0.05	0.14	0.04
7	5	55.16	40.45	1.05	3.09	0.04	0.18	0.03
8	10	52.47	40.12	1.11	6.05	0.05	0.17	0.03

Headings in Table 2:

1. Material number, 2. Y2O3 added amount (weight %).

Practical Example 1

A compounding calculation was conducted so that the zirconia in the grinding particles became 40 %, and to 50 kg of Bayer method alumina (99.6 % Al2O3), 32.6 kg zirconia (96 % Zr02), 0.8 kg of titanium oxide (95 % TiO2) which corresponds to 2.5 in weight % relative to the zirconia, were mixed and combined, and then, yttrium oxide (99.9 % Y2O3) was added in an amount of 0.05, 0.1, 0.5, 1, 2.5, 5, 10 weight % relative to the total amount of the above described three types of materials, and this was then melted using an electrical oven at 95 V, 300 kV, and after that, it was quickly solidified, and melt cast materials were obtained for each addition amount.

Moreover, for the sake of a comparison, a melt cast material where the addition amount of the yttrium oxide was 0 weight %, was also cast.

The values obtained from the analysis of this cast materials, are shown according to the presented in table 2.

After that, the obtained cast material was repeatedly crushed by using an impeller breaker and a crusher, and particle sizes of # 24, and # 60, as determined according to the procedures of the JISR-6001, were withdrawn and obtained.

The ratio of the zirconia crystalline phases of the particle material group # 24, determined by X-Ray Diffraction analysis, is shown according to the presented in Table 3.

Table 3:

第 3 表

1 試料番号	2 正方晶 ZrO_2 (%)	3 単斜晶 ZrO_2 (%)	4 立方晶 ZrO_2 (%)
1	30.1	69.9	0
2	32.1	67.9	0
3	70.7	29.3	0
4	87.9	12.1	0
5	100	0	0
6	100	0	0
7	100	0	0
8	85.8	0	14.2

Headings in table 3:

1. Experimental Material number, 2. tetragonal Zr02 (%), 3. monoclinal crystal phase ZrO2 (%), 4. cubic crystal phase ZrO2 (%).

As it is clear from the results of the X-Ray Diffraction Analysis, if yttrium oxide is added, compared to the alumina-zirconia-titania type grinding particles according to the previous technology where there is no such addition (Experimental material number 1), it is concluded that there is a trend of a significant increase of the tetragonal crystalline phase amount. And especially, it was confirmed that by the addition of an additive amount in the range of 1 ~ 5 weight %, there was a 100 % tetragonal crystal phase

crystal separation. Also, in the case of the addition of 0.05 weight %, there was a corresponding trend of increase of the amount of the separated tetragonal crystal phase, however, there was no significant difference with the previous technology material, and also, if the added amount exceeded 10 weight %, a separation of a cubic crystalline phase was observed.

On the other hand, at the time when the separation of the initial alpha-Al2O3 of for example a material according to the previous technology (Experimental material 1) and material where the added amount of the yttrium oxide was 0.5 weight % (Experimental material 3), with the same # 24 particle size, was observed by using a metal observation microscope, the results that are shown according to the presented in Figure 1 (A), (B) and Figure 2 (A), (B), were obtained. In each case, the magnification was x 100, and Figure 1 (A), (B), represents an enlarged microphotograph of the Experimental material 1, and its model diagram, and Figure 2 (A), (B), represents an enlarged microphotograph of the Experimental material 3, and its model diagram.

Moreover, in both figures, 1 represents the alumina-zirconia co-crystalline material, and 2 - the alpha-Al2O3 initial crystals.

As it is clear from Figure 1 and Figure 2, in the case of the material with the addition of the yttrium oxide, the separation of the initial alpha-Al2O3 crystals was significantly suppressed, and it was confirmed that the predetermined co-crystalline mixed material, was obtained.

Moreover, it was confirmed that the same trend exits in the case of the other materials where yttrium oxide has been added, however, in the case when the added amount was 0.05 weight %, the separated alpha-Al2O3 was at a level of 10 %, and because of the fact that the material according to the previous technology had a level in the range of 10 ~ 15 %, this trend was almost negligible.

After that, grinding performance tests were conducted relative to the materials with the particle size of # 60.

Namely, a polishing belt was prepared and a polishing test was conducted and the results from that test are shown according to the presented in Table 4.

Moreover, the polishing test was conducted as the size of the belt used was 100 x 2500 m/m, and as the material subject to the polishing SUS-304 was used, and the belt speed was set at 150 m/minute, and the pressure was at 5 kg, and a 10 minute polishing was conducted. Table 4 is a table that shows the comparison of the cumulative mass polished amounts that were obtained by this polishing.

Also, the number in the parentheses shows the comparative value when the case of the material obtained according to the previous technology (Experimental material 1) is set as 100.

Table 4:

第4表

1 試料番号	2 累積研削量 (g)
1	94.4 (Ratio 100)
2	95.0 (〃 100)
3	113.0 (〃 120)
4	115.7 (〃 123)
5	119.2 (〃 126)
6	120.6 (〃 128)
7	120.4 (〃 127)
8	96.0 (〃 101)

Headings in the table:

1. Experimental material number, 2. cumulative mass polished amount (g).

Also, the curve line (a) in Figure 3 represents a graph where the cumulative mass polished amounts presented in Table 4, have been plotted.

As it is clear from the above described Table 4 and Figure 3, it has been confirmed that in the case of the co-crystalline grinding particles where yttrium oxide has been added, an extremely excellent polishing strength has been demonstrated compared to the material according to the previous technology where yttrium oxide has not been added.

In this connection, these results are results that correspond to the ratios of the zirconia tetragonal crystalline lattice crystal material, and in the case of the material where the addition amount was 0.05 weight %, there was no significant difference with the material according to the previous technology; and also, in the case when the added amount exceeded 10

weight %, a trend down from the material according to the previous technology was observed due the accompanying separation of cubic crystalline phase material.

However, the addition of the yttrium oxide significantly increases the polishing strength as a total, and not only that, but also, when it is considered that this test results represent only a comparison at the time when a 10 minute polishing has been completed, it is clear that a material is obtained which during the use in practice contributes to the improvement and to achieving extremely excellent polishing performance.

Practical Example 2

A compounding calculation was conducted so that the zirconia in the grinding particles became 40 %, and to 50 kg of Bayer method alumina (99.6 % Al2O3), 32.6 kg zirconia (96 % Zr02), 0.8 kg of titanium oxide (95 % TiO2) which corresponds to 2.5 in weight % relative to the zirconia, were mixed and combined, and then, three types of yttrium oxide containing rare earth mineral ore (the materials with analyses values shown according to the presented in Table 1) was added in an amount of 1, 2.5, 5 weight % relative to the total amount of the above described three types of materials(zirconia, alumina, titania), and this material was then melted using an electrical oven at 95 V, 300 kV, and after that, it was quickly solidified, and melt cast materials were obtained for each addition amount.

The values obtained from the analysis of this cast materials, are shown according to the presented in table 5. Moreover, the experimental material number 1 is the same as that in the case of the Practical Example 1 and it is a material according to the previous technology where yttrium oxide has not been added.

Table 5:

1 2

第 5 表

試料番号	Y_2O_3を含む希土類鉱物の添加量 (wt%)	Al_2O_3	ZrO_2	TiO_2	*	Fe_2O_3	SiO_2	Na_2O
1	0	56.94	41.61	1.20	—	0.05	0.12	0.08
9	1	57.36	40.97	1.04	0.42	0.05	0.13	0.03
10	2.5	56.56	41.04	1.09	1.05	0.06	0.16	0.04
11	5	56.19	40.33	1.12	2.11	0.05	0.17	0.03

Headings in Table 5:

1. Experimental material Number, 2. Added amount of yttrium oxide containing rare earth mineral ore (weight %).

*Rare earth type other than Y2O3.

After that, the obtained cast material was repeatedly crushed by using an impeller breaker and a crusher, and particle sizes of # 24, and # 60, as determined according to the procedures of the JISR-6001, were withdrawn and obtained.

The ratio of the zirconia crystalline phases of the particle material group # 24, determined by X-Ray Diffraction analysis, is shown according to the presented in Table 6.

Table 6:

1 2 第 6 表 3 4

試料番号	正方晶 ZrO_2 (%)	単斜晶 ZrO_2 (%)	立方晶 ZrO_2 (%)
1	30.1	69.9	0
9	96.4	3.6	0
10	100.0	0	0
11	100.0	0	0

Headings in table 6:

1. Experimental Material number, 2. tetragonal Zr02 (%), 3. monoclinal crystal phase ZrO2 (%), 4. cubic crystal phase ZrO2 (%).

As it is clear from the results of the X-Ray Diffraction Analysis, if yttrium oxide containing rare earth mineral ore is added, the same way as in the case of the addition of yttrium oxide, compared to the alumina-zirconia-titania type grinding particles according to the previous technology where there is no such addition (Experimental material number 1), it is concluded that there is a trend of a significant increase of the tetragonal crystalline phase amount.

And it was confirmed that by the addition of an additive amount in the range of 2.5 ~ 5 weight %, there was a 100 % tetragonal crystal phase crystal separation.

After that, grinding performance tests were conducted relative to the materials with the particle size of # 60.

The experimental conditions are the same as those in the case of the Practical Example 1 and the results from that test are shown according to the presented in Table 7.

Table 7:

第7表

1 試料番号	2 累積研削量 (g)
1	94.4 (Ratio 100)
9	118.7 (〃 126)
10	120.0 (〃 127)
11	119.2 (〃 126)

Headings in the table:

2. Experimental material number, 2. cumulative mass polished amount (g).

Also, the curve line (b) in Figure 3 represents a graph where the cumulative mass polished amounts presented in Table 7, have been plotted.

As it is clear from the above described Table 7 or Figure 3, it has been confirmed that in the case of the co-crystalline grinding particles where yttrium oxide containing rare earth mineral ore has been added, the same way as in the case described in the Practical Example 1 where yttrium oxide was added, an extremely excellent polishing strength has been demonstrated for the obtained co-crystalline grinding particles.

Practical Example 3

A compounding calculation was conducted so that the zirconia in the grinding particles became 40 %, and to 50 kg of Bayer method alumina (99.6 % Al2O3), and to 32.6 kg zirconia (96 % Zr02), 1.7 and 4.9 kg of titanium oxide, which corresponds to 5 and 15 weight % relative to the zirconia, were mixed and combined, and then, yttrium oxide was added in an

amount of 0.5 weight % relative to the total amount of the above described three types of materials. And for this material, the results from the analyses of the cast material, the ratio of the zirconia crystalline lattice types according to the X-Ray Diffraction for the particle size # 24, and the cumulative mass polished amount for the particle size # 60, were measured.

These results are correspondingly shown according to the presented in Table 8, Table 9 and Table 10.

Moreover, for the sake of a comparison, the values in the case when there was no addition of yttrium oxide regarding the material where 2.5 weight % of titanium oxide was added, and the materials with the corresponding titania addition amounts, are also reported.

Also, in each case the testing methods are the same as those reported according to the Practical Example 1 and the Practical Example 2.

Table 8:

第8表

試料番号	TiO_2 添加量 (%)	Y_2O_3 添加量 (wt%)	Al_2O_3	ZrO_2	TiO_2	Y_2O_3	Fe_2O_3	SiO_2	Na_2O
1	2.5	0	56.94	41.61	1.20	–	0.05	0.12	0.08
4	2.5	0.5	57.65	40.85	1.02	0.27	0.03	0.14	0.04
12	5	0	57.06	40.63	2.06	–	0.03	0.18	0.04
13	5	0.5	56.78	40.71	2.04	0.25	0.04	0.15	0.03
14	15	0	54.16	39.72	5.91	–	0.03	0.14	0.04
15	15	0.5	53.41	40.24	5.83	0.29	0.04	0.15	0.04

Headings in table 8:

1. Experimental material number, 2. TiO2 added amount (%), 3. Y2)3 added amount (%).

Table 9:

第9表

試料番号	正方晶 ZrO_2 (%)	単斜晶 ZrO_2 (%)
1	30.1	69.9
4	87.9	12.1
12	33.0	67.0
13	90.2	9.8
14	34.2	65.8
15	93.6	6.4

Headings in Table 9:

1. Experimental Material number, 2. tetragonal Zr02 (%), 3. monoclinal crystal phase ZrO2 (%).

Table 10:

第10表

1 試料番号	2 累積研削量 (g)
1	94.4 (Ratio 100)
4	115.7 (〃 123)
12	95.0 (〃 100)
13	112.5 (〃 119)
14	92.0 (〃 97)
15	117.3 (〃 124)

Headings in Table 10:

1. Experimental material number, 2. cumulative mass polished amount (g).

As it is clear from the tables, it is shown that together with the increase of the addition amount of the titanium oxide, there is a trend of increase of the ratio of the remaining present tetragonal crystalline phase Zr02, however, to that, also, by the addition of the yttrium oxide, a significant increase trend was observed.

Practical Example 4

The materials obtained as compounding calculations were conducted so that the zirconia in the grinding particles became 25 % and 32 %, and relative to 50 kg and together with that 24.5 kg of Bayer method alumina (99.6 % Al2O3), and 16.6 kg and together with that 11.5 kg of zirconia (96 % ZrO2), correspondingly as weight percent, 0, 2.5, 5, 10, 15, 20, 30 and 40 % of titanium oxide (95 % TiO2) were added, and the materials where compounding calculations were conducted so that the zirconia in the grinding particles became 25 %, and where relative to 50 kg of Bayer method alumina (99.6 % Al2O3); and 16.6 kg of zirconia (96 % ZrO2), correspondingly as weight percent, 0, 5, 10, 15, 20, 30 and 40 % of titanium oxide (95 % TiO2) were added, and then yttrium oxide was correspondingly added in an amount of 0.5 weight % relative to the total amount of the above described three types of materials, were correspondingly then melted by an arc heat using an electrical oven, and after that, it was quickly solidified, and these materials were then made into particles by following the usual grinding

particle manufacturing methods, and they were made into JIS #12 grinding particles.

These materials, namely, relative to the types without the yttrium oxide addition, which contain 25 % zirconia and 32 % zirconia, and the type where yttrium oxides has been added and which contains 25 % zirconia, the break resistance measurement test was conducted. For the break resistance measurement test the single particle break strength was used. In this method, the experimental material is granulized to a particle size in the range of 1680 ~ 2000 microns, and by the shrinkage method it is made into a small experimental material, and from within that sample, randomly, 100 units are taken out, and these are measured for their pressure resistance strength one by one, by using a 2 ton amsura compressing equipment. The average value of these measurements was used as the value for the single particle break pressure strength.

The single particle break pressure strength of these grinding particles is shown according to the presented in Table 11 and the relationship between the single particle break pressure strength and the TiO2/ZrO2 ratio, is presented in Figure 4.

Table 11:

1 2

第11表

試料番号	タイプ	TiO_2/ZrO_2 (%)							
		0	2.5	5	10	15	20	30	40
16	Y_2O_3 無添加 ZrO_2 25% タイプ 3	46.0	48.8	51.9	61.0	60.0	58.9	52.2	46.7
17	Y_2O_3 無添加 ZrO_2 32% タイプ 4	46.3	47.5	53.8	63.0	63.3	62.0	49.3	45.0
18	Y_2O_3 添加 ZrO_2 25% タイプ 5	48.1	—	55.8	64.7	64.2	63.3	54.1	48.0

Headings in Table 11:

1. Experimental material number, 2. type, 3. type without addition of Y2O3, and 25 % ZrO2, 4. type without addition of Y2O3 and with 32 % ZrO2, 5. type with the addition of Y2O3 and with 25 % ZrO2.

As it is clear from the presented in Figure 4, in the case of any of these types of materials, when the ratio TiO_2/ZrO_2, expressed as weight %, is within the range of 10 ~ 20 %, the strength shows a maximum value, and when the ratio becomes 40 %, there is a decrease. And especially, in the case of the material where yttrium oxide has been added, it was confirmed, naturally, that the type of material where the amount of the ZrO_2 was 25 % is a material which demonstrates an especially excellent break resistance performance compared that in the case when 32 % of zirconia has been added.

As described here above, in the case of the present invention, it is an invention about an alumina-zirconia-titania type grinding material, that is formed as to alumina, zirconia and titania are added and melted, and then quickly cooled, and then, as another melt additive material, yttrium oxide or yttrium oxide containing rare earth mineral ore is contained, and by that, it becomes a material where the maximum remaining zirconia tetragonal crystalline phase is 100 %, and also, even though it is a grinding material that is formed from an alumina-zirconia co-crystalline material with a relatively high amount of zirconia, the amount of the separated (precipitated) initial crystals of the alpha-Al_2O_3 is suppressed to less than 5 %, and because of that it is possible to suggest a material which has a significantly improved grinding performance.

Consequently, it is a material that can be used appropriately in heavy grinding also, and especially, in its light grinding field, and also then, it can be appropriately used relative to titanium alloys.

Also, even though it is an alumina-zirconia type grinding material that contains a relatively small amount of zirconia, compared to the materials according to the previous technology, it is a material whose break resistance strength etc., properties are further improved.

4. Brief Explanation of the Figures

Figure 1 (A), (B), represent the enlarged microphotograph and the model type diagram of the obtained according to the previous technology alumina-zirconia co-crystalline mixed material, which has no added yttrium oxide (Experimental material number 1).

Figure 2 (A), (B), represent the enlarged microphotograph and the model type diagram of the obtained according to one practical example of the present invention alumina-zirconia co-crystalline mixed material, which has added yttrium oxide (Experimental material number 3).

Figure 3 is a diagram showing the relationship between the added amount of yttrium oxide etc., which is found in the grinding material with added yttrium oxide and added yttrium oxide containing rare earth mineral ore, according to the same practical example and another practical example, and the cumulative mass polished amount.

Figure 4 is a diagram showing the relationship between the added amount of the titanium oxide found in the grinding material with relatively low zirconia amount and the single particle pressure break strength.

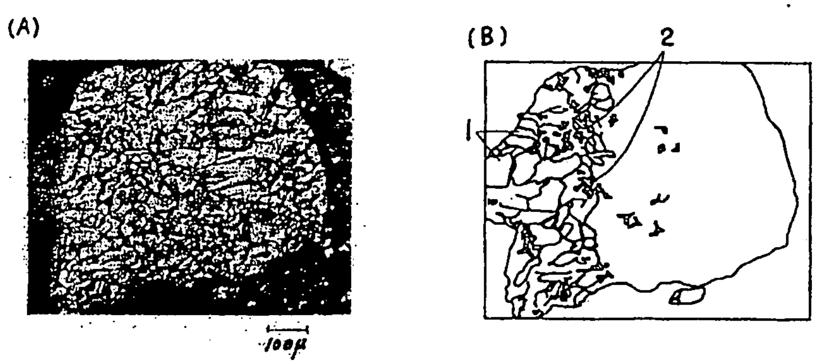

Figure 1: (A) and (B)

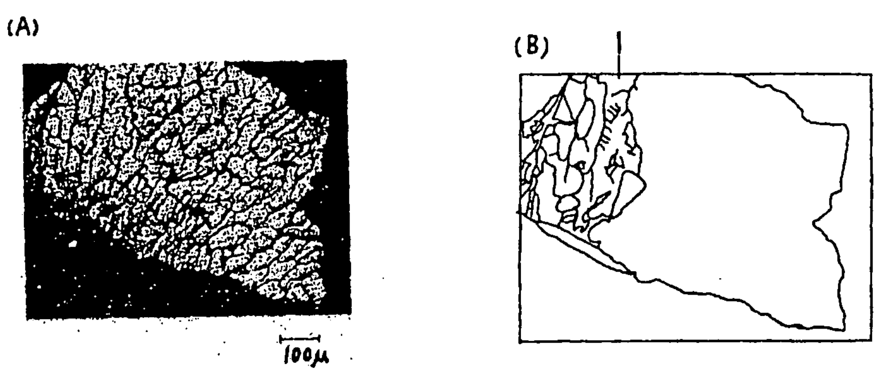

Figure 2: (A) and (B)

第3図

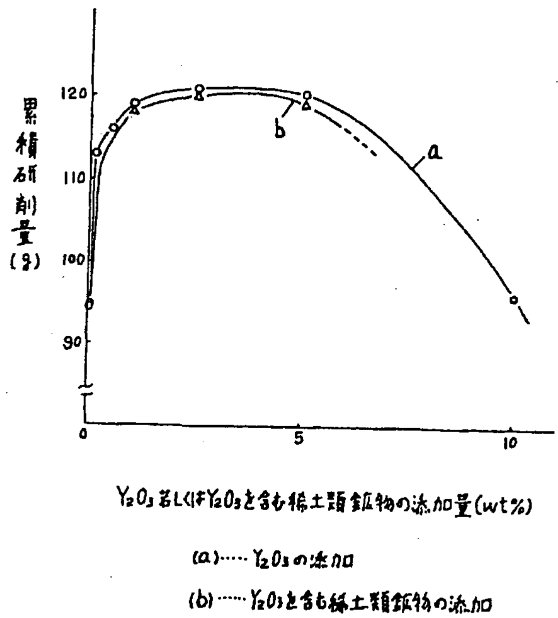

Figure 3:
On the vertical axis – cumulative mass polished amount (g)
On the horizontal axis – added amount of Y2O3 or Y2O3 containing rare earth mineral ore (weight %)

(a)……………………..Y2O3 added amount
(b)…………………….. Y2O3 containing rare earth mineral ore added amount

第4図

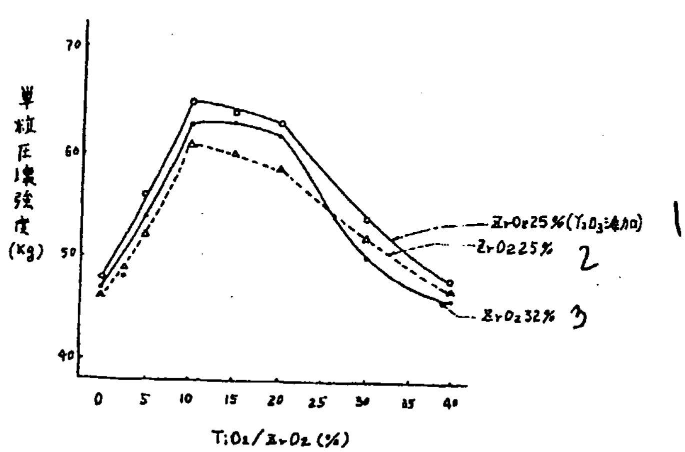

Figure 4:
On the vertical axis – single particle pressure break strength (kg)
On the horizontal axis – TiO_2/ZrO_2 (%)

1. ZrO_2 – 25 % (no Y_2O_3 added)
2. ZrO_2 – 25 %
3. ZrO_2 – 32 %

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